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Research Article

Comparative Study of Organic and Inorganic Legumes for Their Chemical Composition, Nutritional and Amino Acid Profiling- An Analytical Study

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Abstract

The research was conducted to analyze the effect of organic and inorganic agricultural practices on the chemical, nutritional and total amino acid profile of legumes. The moisture content in the analyzed legumes was found higher in inorganically cultivated legumes except soybean. The sugar in organic legumes was found higher than inorganic ones with values ranging from 1.0% to 5.27%.The phosphorus content was found highest in organic and inorganic soybean having values of 5268mg/kg and 4909mg/kg followed by calcium. The predominant essential amino acids were arginine and phenylalanine in organic peas, while as leucine, arginine and phenylalanine were dominant in organic soybean. The total essential amino acid content was found highest in organic legumes. The organic peas and soybean were found containing highest score of amino acids. Lysine was found as limiting amino acid in peas and soybean, while as Bengal gram was found to have valine as limiting amino acid.

Practical Applications: This research is focusing on the health benefits associated with natural organic farming cultivated legumes. The chemical composition, vitamins, minerals and amino acid analysis was found to depict superior results for organically cultivated legumes as compared to conventional ones. That makes organic foods more nutritious and safer for consumption due to devoid of any harmful chemicals and pesticides. Carbohydrates in organic legumes was found lesser than conventional ones that ensure reduction in postprandial blood glucose level upon their consumption and hence decrease in glycemic index. The estimation of BCAA from isoleucine to leucine ratio was found higher in organically grown legumes. The inorganically grown legumes were found having highest content of non-essential amino acids than their organic counterparts. Thus the organically grown legumes could be used for supplementation of weaning and protein rich diets for stimulation of muscle protein anabolism.

INTRODUCTION

Legumes include several important crop plants belong to the family Fabaceae (Leguminosae). The seeds of legumes are usually called as pulses. Legumes are used mainly for human consumption; forage for livestock, oil production and for enhancing soil nutrients by forming symbiotic relation with nitrogen fixing bacteria [1]. Legumes are the second most important agricultural grown commodities after cereals and regarded as a sustainable and inexpensive meat alternative globally. They are richer sources of proteins with essential amino acids, fiber, lower glycemic index carbohydrates, unsaturated fats, higher bioactive compounds, vitamins and minerals [2]. These dietary components play an important role in enhancing health by decreasing production of insulin and preventing chronic diseases such as cancer, diabetes, obesity and cardiovascular disease. The peptides in legumes possess antimicrobial activity, cholesterol lowering property, blood pressure-lowering ability, antioxidant property, antithrombotic and enhance the absorption of minerals [3]. Legumes contain higher protein content than other crops due to symbiotic association of nitrogen fixing bacteria within their root nodules. Organically grown crops are gaining much interest among consumers due to their health benefits than conventional foods and are more sustainable to the ecosystem [4]. Organic foods are claimed by various health authorities to be more nutritious and are devoid of any harmful chemicals and pesticides. Organic agriculture leads to ecological sustainability in economically backward countries, contributes to employment of local resources and is considered highly cost effective that fetch a premium price higher than conventional system. The energy consumption in organic system is three to four times lesser than conventional system and produces six times more biomass per unit of energy consumed. The organic system enhances water management practices, minimum tillage, effective recycling of organic matter, biological pest control, soil fertility and biodiversity [5]. Keeping in view the health benefits of organic agriculture and legumes in human consumption pattern, the research was conducted to analyze the nutritional composition, vitamin and mineral content and amino acid analysis in both conventionally and organically grown important legumes. This research is an excellent interpretation of the effect of organic and synthetic fertilizers on chemical, functional and nutritional characteristics.

MATERIAL AND METHODS

Materials

The peas, Bengal gram and soya bean were cultivated organically and conventionally in the agricultural farm of CSK Himachal Pradesh Agricultural University, Palampur. The selected pulses were dried and ground followed by passing through sieve no. 72 (British Sieve Standards). The resulting flour of each sample was stored in airtight containers under refrigerated conditions for further analysis.

Chemical composition

The proximate composition of each legume was done by following the standard methods of AOAC (2005).

Estimation of chemical elements

The estimation of chemical elements was done by means of an inductively coupled plasma optical emission spectrometer with axial viewing coupled with cyclonic spray chamber, solid state detector and concentric nebulizer. The instrumental conditions are set up at nebulization gas flow rate of 0.7 L min^{-1} under radiofrequency power of 1.3kW. The analytic signals for different elements detected at different wavelengths were: Ca II (317.933 nm), P I (213.613 nm), K II (766.491 nm), Na I (589.592 nm), Mg II (285.213 nm), Fe II (238.204 nm) and Mn II (259.372 nm).

Estimation of Vitamins

The estimation of vitamins was carried out with the instrumental method of micro column HPLC equipped with multi-channel UV-VIS detection. The system was coupled with a switching valve to direct the flow of solvent towards one or another column. Hexane was used for liquid-liquid extraction and a silica cartridge was used for liquid-solid extraction. The micro columns were filled with Silasorb by using 6% diethyl ether in hexane as eluent and detection of vitamin A was done at 320 nm and for vitamin E at 220 nm. The HPLC analysis was performed on a Cl8 column with methanol-water in the ratio of 95:5 was used as eluent and variable-wavelength UV detector was used for detection of highest absorption wavelength of vitamins. The HP-LC system was precalibrated with pure standards of known concentrations based on their extinction coefficients and purity based on chromatographic absorbance patterns that together gave a quantitative response factor for each component to be analyzed.

Amino acid analysis

The amino acid analysis was done by HPLC System equipped with a dual UV/VIS detector, fluorescence detector, column heater, degasser and an auto sampler with derivatization function. The reverse phase C18 HPLC column with dimensions 110 mm x 4.6 mm having internal diameter of 5μm was used at a flow rate of 0.6ml/min with injection volume of 50μL. A mobile phase gradient coupled with temperature gradient program was utilized for the separation of amino acids. The column eluent underwent post column derivatization with ninhydrin reagent for calorimetric detection or with o-phthalaldehyde reagent for florescent detection. Ninhydrin-positive substances based on amino acids were detected at 570 nm; ninhydrin-positive substances based on amino acids, such as proline were detected at 440 nm. Amino acids were detected and quantified by relating the peaks with internal standard mixture chromatographed.

Protein Quality Evaluation

Essential amino acid index (EAAI): EAAI was calculated using the method as described by Oser **et al.**, by using the ratio of relative Essential amino acids in the test protein as compared to the respective values in whole egg protein (Cheftel et al.,).

$$EAAI = n\sqrt{\frac{Lys_a \times Tyr_a \times \ldots\ldots \times His_a}{Lys_b \times Tyr_b \times \ldots\ldots \times His_b}}$$

Where "a" is the amino acid in test sample and "b" is the amino acid in reference protein sample.

Nutritional Index: Nutritional index was calculated as a function of Essential amino acid index and total protein as described by Ijarotimi.

$$Nutritional\ index(\%) = \frac{Essential\ amino\ acid\ index \times protein\ (\%)}{100}$$

Biological value: Biological value was calculated according to the equation suggested by Oser et al.,

$$Biological\ value = 1.09 \times Essential\ amino\ acid\ index - 11.7$$

Protein efficiency ratio

As per joint report of WHO/FAO (1991) expert's consultation, it was reviewed and suggested to replace the method of protein efficiency ratio assay using rat growth, and had been concluded unsatisfactory. Thus, protein efficiency ratios (PERs) on the basis of interaction between Leucine-proline, and Leucine-tyrosine were calculated using the modified regression equations as described by Alsymer et al.,

PER-1= -0.684+0.456(leu)-0.047(pro)

PER-2= -0.468+0.454(leu)-0.105(tyr)

Amino acid score: Amino acid score (%) for infants (pre-school) and adult were calculated as the ratio of observed value of amino acid (g/100g of protein) to the reference pattern as provided by FAO/WHO (2007).

Statistical Analysis: Experimental data was analyzed by analysis of variance (ANOVA) in triplicate. All statistical analysis was performed using commercial statistical package SPSS (16.0, Chicago, IL, USA).

RESULTS AND DISCUSSION

Chemical composition of organic and conventionally grown Legumes

The proximate compositions of the organically and inorganically grown legumes are represented in Table 1. The moisture content in all the analyzed legumes was found to be higher in inorganically cultivated legumes except soybean. The moisture content of the organic legumes depicted values closer to or lesser than 10% as observed in peas (8.67%), soybean (9.10) and Bengal gram (10.12%). This ensures long term storage stability and overall quality of organic legumes by prevention against biochemical reactions and mold infestations, thus organic legumes have an important role in ensuring the safety of foods [7-11]. The lesser moisture retention capacity in organic legumes leads to higher amount of dry matter than conventionally produced legumes and hence is having economic importance besides health benefits to both consumers and processors. The higher value of moisture content in organic pea as compared to its inorganic one (8.82%) could be attributed to its higher canopy that are having the capacity to trap more moisture [6]. Most of the analyzed inorganic legumes were found to possess moisture content higher than 10% as observed in peas (10.39%), and Bengal gram (10.67%). The higher moisture in inorganic legumes leads to rapid rate of deterioration and dry matter loss due to mold attack, sprouting, higher respiration rate, heating and insect damage.

A significant difference was found among the carbohydrate content between the organic and inorganic legumes with organic legumes showing the lesser values than the conventional ones. The carbohydrate content varied from 35 to 72.05% in organic legumes, while in organic ones its value ranged from 36.79 to 72.64% with Bengal gram depicted the higher amount and soybean the least value. This could be attributed to higher levels of nitrogen associated with the organic soil due to application of bio ferlitizers and humus coupled with symbiotic association of nitrogen fixing bacteria [7]. This higher concentration of nitrogen have a significant effect on decreasing the carbohydrate content in organically cultivated agricultural commodities as validated earlier by Weston and Barth.. The starch present in soybean is less than 1% and the carbohydrate in this cereal comprises one half of nonstructural oligosaccharides and low molecular weight sugars, while the other half consists of structural polysaccharides (Karr-Lilienthal et al.). The lesser concentration of carbohydrates in organic legumes as revealed in the study could ensure reduction in postprandial blood glucose level upon their consumption and hence decrease in glycemic index [8]. Thus the organically grown legumes were found to have a nutritional significance as compared to their conventional ones.

The protein content was found to vary from 11.14 to 37.54% in organic legumes and 10.25 to 35.38 % in inorganic legumes. The increased amount of nitrogen in organically maintained soil along with assimilated nitrogen from atmosphere within root nodules of the legumes are converted into ammonia that get assimilated into amino acids and proteins. Thus the increased levels of nitrogen in organically grown crops lead to a higher concentration of proteins and reduction in carbohydrates. This corroborated with the findings of the present research and experiments conducted earlier by Salunke and Desai.The highest protein content was found in the soybean that comprises about 70% of storage proteins, glycinin and conglycinin. The protein content in pea was found to be 18.30% and 21.94% in organic and inorganic produces that are considered more digestible and possess least allergenic responses as compared to soybean [9]. The Bengal gram was found to contain an excellent amount of protein with values of 22.88% in organic and 18.85% in inorganic one. Its protein is rich in lysine and is deficient in sulphur containing amino acids that is considered a low cost protein rich supplement to cereal based or vegetarian diet and aids in alleviating protein malnutrition in developing countries [10]. An exceptional trend was observed with respect to fat content in which the inorganic cultivated legumes showed higher values ranging between 0.58% in Bengal gram to 14.11% in case of soybean. This trend of increase in fat content in inorganic legumes could be attributed to higher concentration of nitrogen and phosphorus associated with application of vermin compost and bio fertilizers that are having negative impact on fat accumulation of the products [11]. The increase in concentration of soil enriching nutrients results have been reported to cause reduction in fat content [12]. The highest percentage of fat in soybean (13.62% in organic and 14.11% in inorganic) are stored as triglycerides in special organelle, oil bodies and is highly unsaturated consisting of a complex mixture of palmitic, stearic, oleic, linoleic, and linolenic fatty acids. The lowest fat content was found in Bengal gram with concentration of 0.68% in organic and 0.58% in organic. It is due to this lowest fat content that recommended Bengal gram as an energy dilute food by WHO/FAO. (2003).The fiber content in the experimental samples was found as low as 3.45% in organic Bengal gram and the highest content of 8.14% in organic peas. The inorganic legumes were found to possess least fiber of 2.58% in case of Bengal gram. The fiber in legumes consists of soluble mucilaginous polysaccharides and is having the ability to decrease the exposure of toxic substances and binding of carcinogenic compounds with mucosal linings of colon [13]. The low fiber content in organic soybean (5.52%) could account for their higher energy, excess dry matter, highest digestibility and total digestible nutrient. The ash content in the analyzed legumes was higher in organically grown Bengal gram (3.42%) and peas (3.31%), while as in inorganic legumes it was found higher in soybean (4.90%). The ash content is considered an important indicator of determining the quality of milled flour and its purity. The ash gives an index of mineral content mainly phosphorous, calcium, potassium, and magnesium, zinc, iron and copper. The ash content in the present legumes was found in the range recommended by [14] Pomeranz and Clifto and thus it could be used for animal feeding and human consumption without needing mineral supplementation.

The sugar in the organic legumes was found higher than inorganic ones with values ranging from 1.0% to 5.27%. The highest percentage of sugar was depicted by soybean (5.27 and 5.17%), that account for about half amount of the carbohydrates in the form of soluble sugars along with oligosaccharides as reported earlier by Hou et al. [15],. The sugars in soybean mainly comprises of galactose, fructose, glucose, raffinose, sucrose and stachyose. The least amount of sugars in Bengal gram makes it an effective legume in reducing postprandial plasma glucose levels than other pulses and cereals. Thus among the analyzed legumes the lesser sugar containing Bengal gram and peas could be a healthy source of carbohydrate for those having diabetic complications. The composition sugars in the Bengal gram had been found to be dominated mainly by rhamnose, arabinose, galactose and uronic acids, thus are rich in pectin content than other pulses. Whereas the peas had been found to contain highest amount of uronic acid and hence its pectin is more negatively charged than other pulses. The sugar content gives a measure of physiological activity of a plant and its higher concentration in organic systems had been revealed earlier by Rajasekaran et al. [16], in bioferlitizers applied plots.

Mineral and vitamin composition of analyzed legumes

The mineral composition of the experimental materials showed significant variations among each other and with respect to both organic and inorganic means. The maximum concentration of minerals was observed in inorganically grown legumes except soybean as represented in Table 2. The availability of minerals in soil has been found to have an important role in determining the concentration of mineral accumulation in seeds. Thus the higher mineral concentration in inorganic soils due to application of chemical fertilizers and herbicides accounted for maximum absorption and accumulation of minerals by the growing plants as validated earlier by Pavinato & Rosolem [17]. The phosphorus content was found highest in organic and inorganic soybean having values of 5268mg/kg and 4909mg/kg followed by calcium. The phosphorus in soybean is nutritionally unavailable due to its presence in the form of phytic acid, which could be reduced by different processing techniques like grinding, soaking and cooking. The presence of phosphorus as phytic acid in soybean accounted for its beneficial properties including antioxidant, anti-carcinogenic, prevention of diabetes and anti-inflammation [18]. Pulses in organic systems are lacking the ability to replenish the phosphorus supplies post harvesting and are thus facing other nutrient problems due to their higher demand for phosphorus [19]. Calcium was found to be highest in soybean and lowest in organic Bengal gram (1256mg/kg) and inorganic peas (1304mg/kg). Calcium is an essential minerals used for bone and teeth formation and plays an important part in combating osteoporosis faced mainly by women. The soils with excess of calcium have been found to cause deficiency of potassium and vice versa as confirmed by FAO and ITPS, (2015). This is justified by the findings of given research. The organic farming permits only the usage of manure, bone meal and compost that undergoes the chemical transformation so that nutrients would be available to the plants. Whereas in inorganic farming synthetic N, P and K are readily available for utilization by the plants and thus most of these macro nutrients are assimilated by plants grown under inorganic farming systems [20]. This justification could be attributed to potassium that depicted higher concentration in inorganically grown soybean (17115mg/kg). However the contradicting results was found in respect to potassium in organic peas (12411mg/kg) and Bengal gram (10737mg/kg) which could be attributed to the mobilization of minerals from pods of the legumes to seeds as revealed earlier by the findings of Hocking and Pate (1977) that reported that accumulation of minerals in seeds due to their mobilization from pods accounted to 5–39% of the total absorbed minerals. The sodium content was found lowest in all the organically grown legumes and thus makes these beneficial for consumption by persons suffering from hypertension. Iron that is an essential element needed for transporting oxygen and nutrients to body cells was found highest in organic peas (61mg/kg) and soybean (63mg/kg), while as the inorganic Bengal gram depicted higher content (49mg/kg) as compared to organic produce. The higher iron in the legumes could be used for preventing deficiencies to vegetarian, as iron stores are lowest in vegetarian diets [21]. Iron deficiencies can result in fatigue, weakness, shortness of breath, pale skin, headache, heart palpitations and inability to maintain body temperature. Anemia caused by iron deficiency can results in premature delivery in pregnant women and higher infant mortality. The phytate, or phytic acid present in legumes are the inhibitors of iron absorption, which can be mitigated by soaking or sprouting of legumes [22]. The highly significant enhancer for absorption of iron is vitamin C that has the ability to increase the iron absorption up to 3-6 folds in plant foods and in overcoming the inhibitory effect of phytic acid in legumes [23]. Thus the higher content of vitamin C in peas (20.68mg/kg) and Bengal gram (10.80mg/kg) accounted for higher iron absorption in the analyzed legumes. The higher levels of nitrogen in the organic soils lead to increased proteins and lower carbohydrates content. This reduction in carbohydrates accounted for the lesser content of vitamin C in organically produced legumes as vitamin C is synthesized from carbohydrates. Vitamin A also has been found to enhance absorption of non-haem iron. Thus the experimental legumes were found to have a significant content of vitamin A which favors the absorption of vitamin A and plays an important role in enhancing the immune system, skin health and healthy vision. Legumes are good sources of thiamine and in the present research the inorganic pea (0.24mg/100g) and soybean (0.20mg/100g) were found to contain the higher amount of Vitamin B1. The synthetic Nitrogen fertilizers have been found to increase the concentration of vitamin A and vitamin B1. Excess application of nitrogen fertilizers leads to an increased concentration of NO_3 that have a negative effect on ascorbic acid [24]. Thiamine plays an important role in the production of energy from dietary carbohydrates and fats and its deficiency leads to beriberi, optic neuropathy, Leigh's disease and disorders in nervous system [25].**Amino acid analysis**

The amino acid analyses results of the legumes are presented in Table 3. The amino acid composition of both the organic and inorganic grown legumes depicted a significant difference with respect to both essential and non-essential amino acids. The predominant essential amino acids were found to be arginine (1920.10mg/100g) and phenylalanine (1069.07mg/100g) in organic peas, while as leucine, arginine and phenylalanine were dominant in organic soybean with leucine showing the maximum value of 1386.42mg/100g. A contrasting trend was observed in inorganic Bengal gram wherein leucine arginine and phenylalanine depicted highest concentration than organic counterparts. The analyzed legumes were found to contain the lowest amounts of sulphur containing essential amino acids cysteine and methionine, which in agreement with the findings of Margier et al., [26]. The concentration of each amino acids had been found to be determined be the nitrogen content and methionine, cystine and tryptophan had been reported to depict least correlation with nitrogen [27]. The lesser content of sulphur containing amino acids in the analyzed organically grown pulses could be attributed to the deficiency of sulphur in organic soils as deficiency of sulphur reduces the concentration of S-containing amino acids [28]. The branched-chain amino acids (BCAA, i.e., Leu, Ile, and Val) were found higher in organic peas and soybeans, while the conventionally grown Bengal gram was observed to possess higher BCCA content. The application of phosphorus as NPK fertilizers enhances root development in Bengal gram that in turn leads to increase in nitrogen uptake and thus higher amino acids concentration. Arginine, leucine, and methionine had been reported to represent a highly negative correlation with oil content in soybean as compared to other essential amino acids [29]. This is confirmed in the given results where the content of these three amino acids were found higher in organic systems that also depicted lowest fat content than conventional ones.

Total amino acid profile of organically and inorganically grown legumes

The Amino acid profiling determined by calculations of amino acids was classified into five groups as shown in Table 3. The total essential amino acid content was found to be highest in organic legumes with peas depicting highest percentage of 49.69% among the analyzed legumes. The inorganically grown legumes were found having highest content of non-essential amino acids than their organic counterparts. Thus the organically grown legumes could be used for supplementation of weaning and protein rich diets for stimulation of muscle protein anabolism. The present study revealed that organically produced legumes proved an excellent source of essential amino acids for vegans and served as best alternative to animal proteins. The total acidic amino acids considered to be excitatory neurotransmitters were found to be higher in inorganically grown legumes with values ranging from 27.71% in soybean to 32.33% in peas. The highest content of glutamic acid in organic peas and soybean accounted for their savory (umami) flavor as it is used as flavoring agents like monosodium glutamate [30]. The higher percentage of aspartic acid was found in inorganically grown peas (2680.78%) and Bengal gram (2052.31%) and in organic soybean (1736.77%). Aspartic acid is considered an important amino acid essential in removing of cellular toxin ammonia that is having a harmful impact in human body by damaging brain, liver and nervous system. The organic peas and Bengal gram showed a significantly marked higher proportion of total basic amino acids with organic peas having highest value of 20.42%. Among the basic amino acids, arginine has been recognized as potential therapeutic agent in patients suffering from cardiovascular diseases and cancers. Histidine plays an essential role in enhancing the immune system by synthesizing leukocytes that are having an important role in combating pathogens. This amino acid is also helpful in reducing bold pressure by relaxing the blood vessels and thus aids in prevention of arteriosclerosis and heart attacks [31]. The basic amino acid lysine is an essential amino acid playing several roles in human body including protein genesis, cross linking of collagen polypeptides, absorption of essential mineral nutrients and metabolism of fatty acids by producing carnitine. The aromatic amino acid that serves as precursors for synthesis of neurotransmitters serotonin, noradrenaline and dopamine are essential for normal brain functioning as reported earlier by Murai et al., were found highest in organic peas, Bengal gram and inorganic soybean. Aromatic amino acids have been found to reduce the risk of diabetic nephropathy (Zhang et al.,). The estimation of BCAA from isoleucine to leucine ratio was found higher in organically grown legumes with values ranging from 2.46 to 2.59. BCAAs suppress breakdown of proteins and acts best energy reservoir during physical activities. BCAAs constitute 21% of total body proteins and 35% of muscle proteins that are involved for the biosynthesis of sterols and ketone bodies [32]. The amino acid leucine in BCAA enhances muscle performance by stimulating muscle protein synthesis and decreasing the duration of muscle soreness. The supplementation of BCAAs has been found to improve the positive health results in patients with liver cirrhosis and thus prevents development of liver cancer [33]. These are also essential in regulating the blood sugar level by stimulating insulin production enabling body cells to metabolize sugars from the blood and by preserving the muscular and liver glycogen reservoirs. BCAAs acts as donors of nitrogen and carbon involved in the formation of other amino acids and are thus essential in enhancing immune system [34].

Amino acid based nutritional profile of selected legumes

Essential amino acid index that gives an index of protein quality and represented as numerical index was found higher in organic soybean (37.78), while as the inorganically grown peas and Bengal gram showed higher EAAI than their organic ones as represented in Table 4. The higher EAAI in inorganic peas and Bengal gram could be attributed to the assimilation of nitrogen by application of fertilizers that leads to an increase in essential amino acids despite lowering in protein content as reported earlier by Sotelo et al., [35]. EAAI was devised as an indicator for determining the nutritional quality of protein by taking into account its entire essential amino acids composition. The essential amino acid index based on the ratio of essential amino acid content relative to that of standard protein ranges from 1 to 100%. Thus the protein quality based on EAAI in the analyzed legumes was found to be intermediate and thus could be regarded essential for normal growth and development of human body. The percentage of the protein that is actually retained by the proteins of the human body was measured from Biological value that was found to follow the same trend as EAAI. Which is in accordance with the findings of Oser, a high degree of correlation was found between essential amino acid indexes and biological values. As biological values is an indicator of how readily the digested protein can be utilized in synthesizing proteins in the cells of the organism. Thus the soybean protein can be the substitute for protein supplements in the athletes and body building persons. Nutritional index is the measurement of the function of essential amino acid index and protein content was found highest in organic soybean (14.18) and Bengal gram. (7.98). Nutritional index is an important tool to assess the required nutritional status of proteins, thus the higher protein content could be associated with higher nutritional index. Protein efficiency ratios based on interaction between Leucine-proline, and Leucine-tyrosine gives the measurement of the weight gain by an organism by consuming a particular protein during the test period were found higher in organic peas and soybean. Organically grown Bengal gram was found to depict the lowest value of 464.95 and 430.65 for both these ratios. The PER is considered an acceptable tool to compare the food values of different proteins. The highest PER values in soybean proteins had been found to meet the protein needs of children's and adults upon consuming at recommended protein intake level of 0.6 g/kg of body weight.

Amino acid scoring of the analyzed legumes

Amino acid scoring based on the essential amino acids content in a protein compared to that presents in reference protein gives an indication of nutritional excellence and in an index of the protein value for growth and tissue maintenance [36]. Amino acid scoring for both infant and adult was estimated with respect to the reference values provided by FAO/WHO, 2007 and displayed in Table 5. The lowest amino acid score for the indispensable amino acids in a protein depicts the most limiting amino acid gives the first approximation of its efficiency of utilization by children. Lysine was found as limiting amino acid in peas and soybean, while as Bengal gram was found to have valine as limiting amino acid. In general the organic peas and soybean were found to contain highest score of amino acids than their inorganic cultivars.

CONCLUSION

The maximum concentration of minerals was observed in inorganically grown legumes except soybean. Essential amino acid index was found highest in organic soybean, while as the inorganically grown peas and Bengal gram showed higher EAAI than their organic ones. The higher content of vitamin C in peas and Bengal gram accounted for higher iron absorption in the analyzed legumes. The present study revealed that organically produced legumes proved an excellent source of essential amino acids for vegans and served as best alternative to animal proteins.

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